Claims

We claim:

1. A system for modeling a graphics object, comprising:

means for providing a model, generation parameters specifying a fixed level-of-detail, and conversion parameters specifying variable levels-of-detail;

means for generating an adaptively sampled distance field having the fixed level-of-detail from the model; and

means for converting the adaptively sampled distance field from the fixed level-of-detail to the variable levels-of-detail while concurrently generating rendering primitives.

2. The system of claim 1 wherein the fixed level-of-detail has a greater resolution than the variable levels-of-detail.

4. The system of claim 1 wherein the fixed level-of-detail has lesser resolution than the variable levels-of-detail.

5. The system of claim 1 wherein the variable levels-of-details are specified by levels in a hierarchy of the adaptively sampled distance field.

6. The system of claim 1 wherein the variable levels-of-details are specified by a maximum error bound of distance values in the adaptively sampled distance field.

7. The system of claim 1 wherein the adaptively sampled distance field includes a plurality of cells storing distance values at each vertex of each cell, and further comprising:

means for selecting particular cells to be converted from the fixed level-of-detail to the variable levels-of-detail to selectively render topological and geometrical features of the model.

8. The system of claim 1 further comprising a user interface comprising:

a first image of the model at the fixed level-of-detail and a fixed viewing distance;

a second image of the model at the variable level-of-detail and the fixed viewing distance;

a third image of the model at the fixed level-of-detail and variable viewing distances; and

a fourth image of the model at the variable level-of-detail and the variable viewing distances, the images concurrently rendered while varying the levels-of-detail and the viewing distances.

9. The system of claim 8 wherein the images are dynamically linked while converting and rendering.

10. The system of claim 8 wherein the user interface further comprises:

means for setting a maximum number of triangles for the variable levels-of-detail;

means for setting an error bound for the variable levels-of-detail; and

means for setting a viewing distance, elevation, and azimuth.

11. The system of claim 8 wherein the user interface further comprises:

means for generating a hint; and

means for blending the adaptively sampled distance field having the fixed level-of-detail with the adaptively sampled distance field having the variable levels-of-detail according to the hint, the means for generating the hint and blending operating concurrently with the means for converting.

12. The system of claim 11 wherein the means for blending operates according to an interpolant.

13. The system of claim 12 further comprising:

means for selecting an interpolation point between the adaptively sampled distance field having the fixed level-of-detail and the hint.

14. The system of claim 11 wherein the means for generating the hint combines selected hint primitives, and wherein the hint primitives are converted to another adaptively sampled distance field prior to blending.

15. The system of claim 14 further comprising:

means for scaling, rotating, and translating the hint primitives during the combination.

16. The system of claim 14 wherein the combination of the hint primitives includes union, intersection, and subtraction of the hint primitives.

17. The system of claim 11 wherein the means for blending operates concurrently on a plurality of fixed adaptively sample distance fields generated from a plurality of models.

18. The system of claim 1 wherein the variable levels-of-detail and the rendering primitives are respectively converted and generated in less than 10 milliseconds.

19. The system of claim 1 wherein the variable levels-of-detail and the rendering primitives are respectively converted and generated at a frame rate of at least thirty frames per second.

20. The system of claim 1 wherein the model is selected from a group consisting of range data, scanned data, triangles, implicit functions,
CSG models, volumes, and Bezier patches.

21. The system of claim 1 wherein the rendering primitives include points, wire-frames, and triangles.

22. The system of claim 1 wherein the system further comprises:
a video game further comprising:
a user interface including game input devices for specifying the variable levels-of-detail; and
means for constraining the variable levels-of-detail.

23. The system of claim 1 wherein the system further comprises:
an animation system further comprising:
means for specifying the variable levels-of-detail; and

means for rendering the rendering primitives as frames in a movie.

24. The system of claim 1 wherein the system further comprises:

an animation system further comprising:

means for specifying the variable levels-of-detail;

means for generating a hint;

means for blending the adaptively sampled distance field having the fixed level-of-detail with the adaptively sampled distance field having the variable levels-of-detail according to the hint, the means for generating the hint and blending operating concurrently with the means for converting; and

means for rendering the rendering primitives as frames in a movie.

25. A method for modeling a graphics object, comprising:

providing a model, generation parameters specifying a fixed level-of-detail, and conversion parameters specifying variable levels-of-detail;

generating an adaptively sampled distance field having the fixed level-of-detail from the model; and

converting the adaptively sampled distance field from the fixed level-of-detail to the variable levels-of-detail while concurrently generating rendering primitives.

26. The method of claim 25 wherein the generation parameters and conversion parameters are provided by a user interface.

27. The method of claim 25 further comprising:

selecting a particular level-of-detail;

generating a first adaptively sampled distance field having the particular level-of-detail from the adaptively sampled distance field having the fixed level-of-detail;

constructing a topological hint from a combination of selected graphical primitives;

generating a second adaptively sampled distance field from the topological hint;

blending the first and second adaptively sampled distance fields to generate a third adaptively sampled distance field; and

rendering the third adaptively sampled distance field to render the model at the particular level-of-detail according to the topological hint.

28. The method of claim 27 wherein the blending operates concurrently on a plurality of fixed adaptively sample distance fields generated from a plurality of models.

29. The method of claim 27 wherein the blending further comprises:

generating a first adaptively sampled distance field for a first model;

generating a second adaptively sampled distance field for a second model;

calling a reconstructing function with a plurality of locations in a third adaptively sampled distance field;

determining first and second distance values for each location respectively from the distance values of the first and second adaptively sampled distance fields;

combining the first and second distance values of each location according to a blending function to produce a blended distance value for each location in the third adaptively sampled distance field; and

storing the blended distance value of each location in the third adaptively sampled distance field to represent a blending of the plurality of the graphics models.

30. The system of claim 1 wherein the generating comprises defining a candidate cell of the adaptively sampled distance field, determining and storing distance values of the candidate cell in a bounded distance tree, recursively subdividing the candidate cell into subdivided cells of the adaptively sampled distance field while determining and storing corresponding distance values of the subdivided cells in the bounded distance tree until a termination condition is reached, and appending the distance values to the corresponding cells to generate the adaptively sampled distance field of the object.

31. The method of claim 25 wherein the generating comprises defining a candidate cell of the adaptively sampled distance field, determining and storing distance values of the candidate cell in a bounded distance tree, recursively subdividing the candidate cell into subdivided cells of the adaptively sampled distance field while determining and storing corresponding distance values of the subdivided cells in the bounded distance tree until a termination condition is reached, and appending the distance values to the corresponding cells to generate the adaptively sampled distance field of the object.

32. The system of claim 1 wherein the rendering primitives are triangles, further comprising:

selecting a particular level-of-detail;

generating a particular adaptively sampled distance field having the particular level-of-detail from the adaptively sampled distance field having the fixed level-of-detail; and

determining the triangles from the particular adaptively sampled distance field, the particular adaptively sampled distance field including a plurality of surface cells storing distance values having corresponding gradients, comprising:

assigning a vertex to a center location of each surface cell, connecting the vertices of neighboring surface cells to form triangles while satisfying a predetermined constraint, and moving each vertex, in a single step, to a new location according to the distance value and corresponding gradient of the vertex to substantially conform the triangles to the surface of the object.

33. The method of claim 25 wherein the rendering primitives are triangles, further comprising:

selecting a particular level-of-detail;

generating a particular adaptively sampled distance field having the particular level-of-detail from the adaptively sampled distance field having the fixed level-of-detail; and

determining the triangles from the particular adaptively sampled distance field, the particular adaptively sampled distance field including a plurality of surface cells storing distance values having corresponding gradients, comprising:

assigning a vertex to a center location of each surface cell, connecting the vertices of neighboring surface cells to form triangles while satisfying a predetermined constraint, and moving each vertex, in a single step, to a new location according to the distance value and corresponding gradient of the vertex to substantially conform the triangles to the surface of the object.